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Progress report: The regional setting of the Kingman fault zone

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Dear Marc,

Here is my report. I found writing it to be useful for straightening out the stratigraphy mentally. Lil Morisi sent me a draft of her master's, which you might want to see sometime. She goes into much greater depth on all these topics.

Sincerely,
Beth

Progress Report:

The Regional Setting of the Kingman Fault Zone

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Introduction

The Kingman fault zone, located along the Penobscot River between Kingman and Howland (figure 1), is a zone of intensely deformed low-grade metamorphic rocks (Morisi, 1984; 1986; Ludman, 1986). The regional significance of this zone is difficult to assess. Well-defined stratigraphic sequences lie to the east and west of this area, but mapping of sufficient detail to extend these stratigraphies up to the fault zone has not been done. Mesostructures within the zone have been described by Morisi (1984; 1986) and Morisi and Ludman (1985), but further work is needed to characterize the microstructures and to determine the mechanisms by which these rocks deformed.

Last summer, I spent July 22 to August 16 studying the regional setting of the Kingman fault zone. To this end, I did reconnaissance work in four fifteen-minute quadrangles cut by or adjacent to the Kingman fault zone: the Boyd Lake, Passadumkeag, Lincoln, and Winn Quadrangles. My goal for these four weeks was to see as great a variety of rock types and structures as possible, in an effort to become familiar with the stratigraphy and structural style of the area. In order to be able to identify the formations in this area, I began by working in the western half of the Boyd Lake Quadrangle, which had been mapped by John Griffin (1971). I used his map to locate outcrops in order to see his map

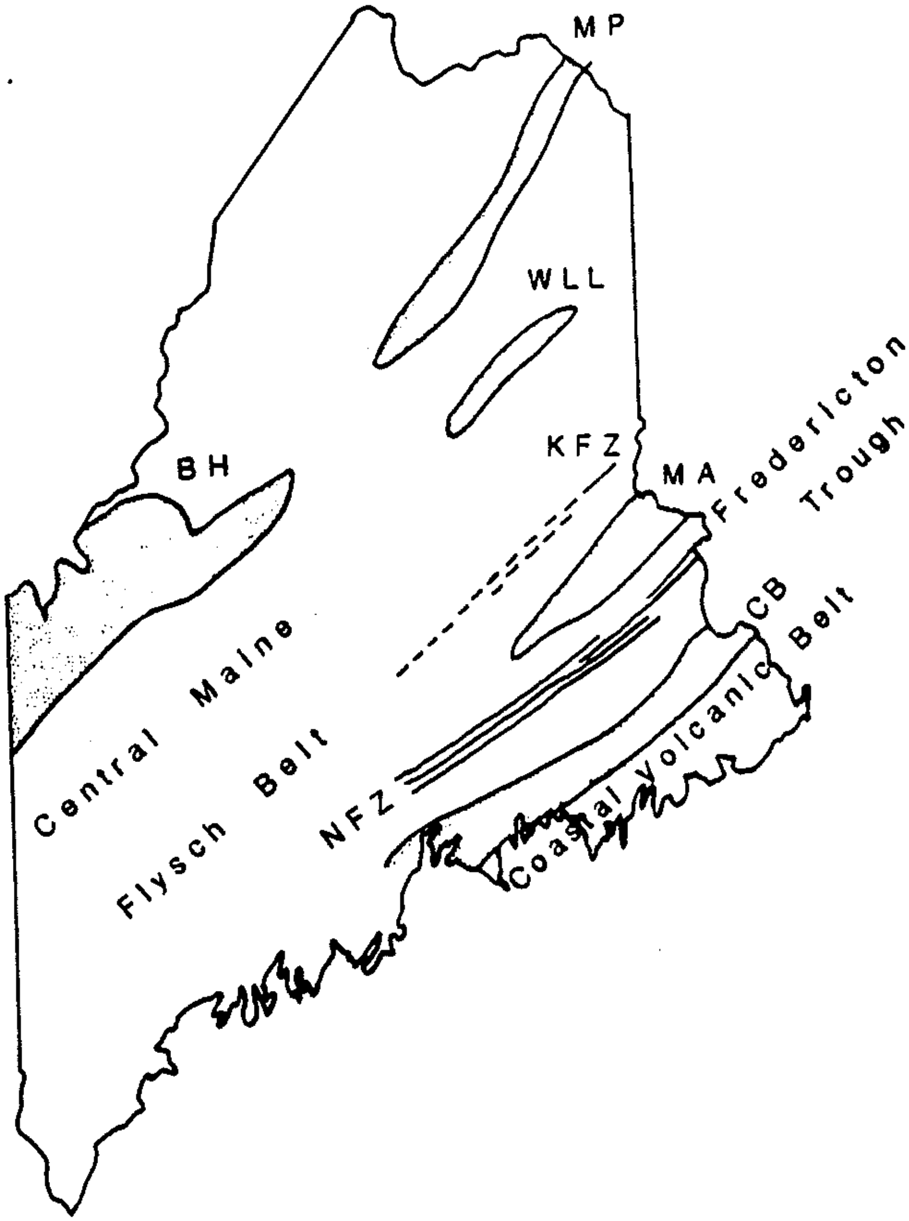


Figure 1. Lithostratigraphic framework of eastern and east-central Maine. KFZ = Kingman fault zone; NFZ = Norumbega fault zone; stipple = pre-Silurian tracts; BH = Bronson Hill–Boundary Mountain anticlinorium; MP = Munsungun anticlinorium; WLL = Weeksboro–Lunksoos Lake anticlinorium; MA = Miramichi anticlinorium; CB = Cookson belt.

from Ludman, 1986

units in a variety of settings. I also followed the field guide written by Ludman and Griffin (1974) for an area west of the Boyd Lake Quadrangle, in order to examine the units and their outcrop style in an area where these formations are better known.

After becoming familiar with the units exposed in this area, I sampled and described as many outcrops distributed over the four quadrangle area as I could. To do this, I relied on outcrop information given on the surficial maps of Boyd Lake (Borns, Caldwell, and Hanson, 1981), Passadumkeag (Borns, 1981), Lincoln (Lowell, 1980), and Winn (Holland, 1981) Quadrangles, on the bedrock maps compiled by Griffin (1971) and Westerman (1983), and on oral communications from Allan Ludman and Thomas Lowell. I spent several days searching for hitherto undescribed outcrops, in an effort to see how easily these could be found. Results were mixed; outcrop is sparse, especially in the northeastern quadrant of the Boyd Lake Quadrangle.

The following sections are based on both my own observations from last summer and the work of others.

Stratigraphy

West

Several authors have published descriptions of the units exposed west of the Kingman fault zone. The reader is referred to Osberg (1968, Waterville area), Osberg, Moench and Warner (1968, Rangeley and Waterville areas), Ludman (1976, Kingsbury-Skowhegan area), Pankiwskyj et al. (1976, from the Buckfield Quadrangle in the west to the Boyd Lake Quadrangle in the east), and especially to Morisi (1984, 1986, this study area) for more detailed descriptions than will be given here. Correlation charts of previous workers are given as figures 2 to 5; the presently accepted stratigraphy is shown in figure 6. As can be seen from the charts, some workers favor a "layer cake" model, while others favor a more complex model of interfingering relationships.

All the units described here have been metamorphosed, in the study area to at least chlorite grade; convention is followed in not using the prefix meta- on rock names. The formations are listed in order of age, from oldest to youngest.

Ordovician-Silurian

Vassalboro Formation: A dominantly thick-bedded (7 cm to 3 m), slightly calcareous sandstone with thin beds of gray

AGE	RANGELEY AREA	WATERVILLE AREA
Devonian(?)	Not Exposed Seboomook (?) Formation	Not Exposed
Sil or Dev	Madrid Formation	Vassalboro Formation
Silurian and Silurian(?)	Smalls Falls Formation Perry Mountain Formation	Waterville Formation
	Rangeley Formation	Mayflower Hill Formation Not Exposed

Figure 2. Correlation chart of the Rangeley and Waterville areas. After Osberg, Moench, and Warner, 1968.

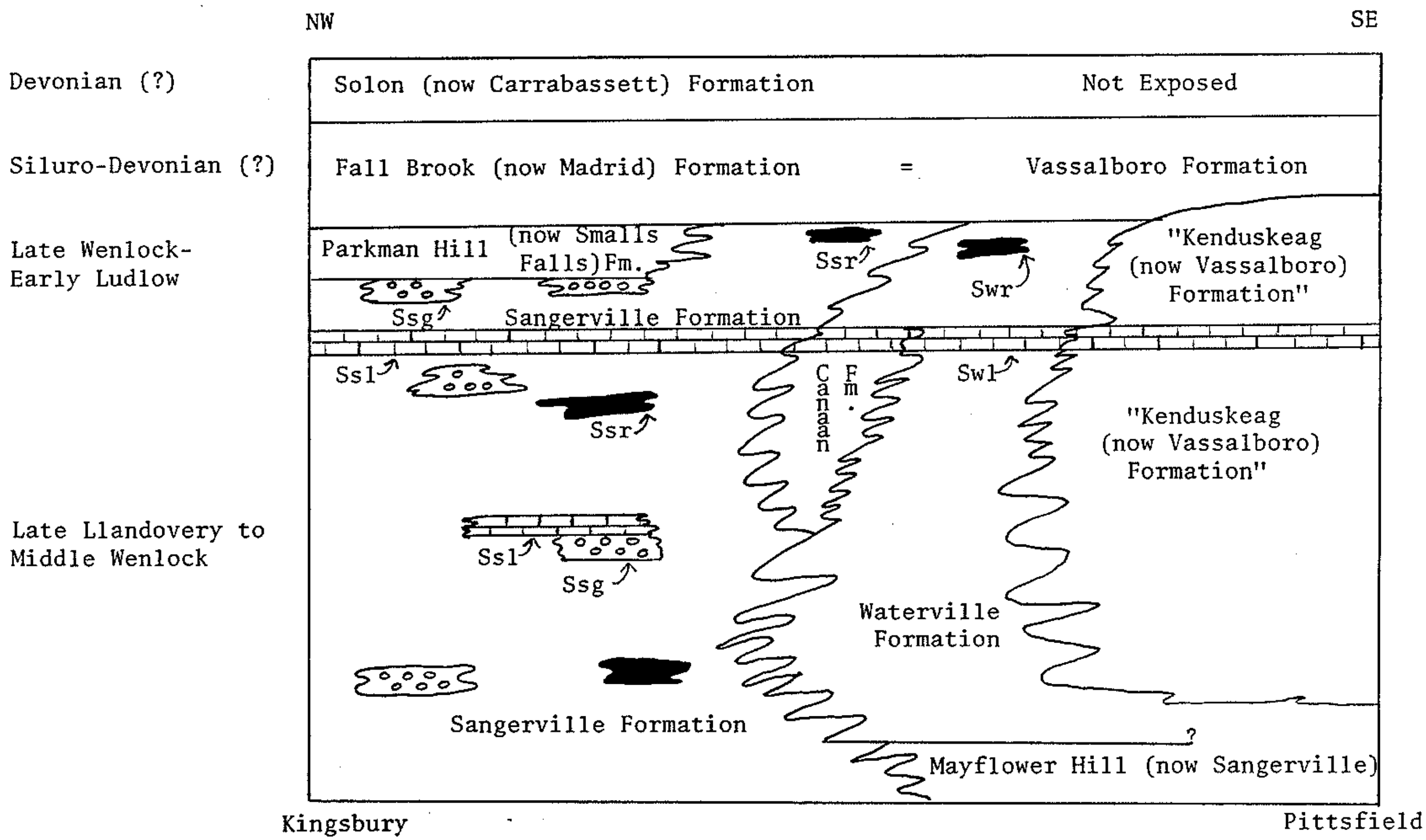


Figure 3. Inferred pre-Acadian Stratigraphic Relationships. After Ludman and Griffin, 1974.

	AGE	RANGELEY/PHILLIPS	KINGSBURY/SKOWHEGAN	WATERVILLE/VASSALBORO
	Devonian(?)	Seboomook Formation	Solon (now Carrabassett) Formation	Not Exposed
	Devonian and Late Ludlow(?)	Madrid Formation	Brighton (now Madrid) Formation	Vassalboro Formation
Silurian	Early Ludlow	Smalls Falls Formation	Eddy (now Smalls Falls) Formation	
Silurian	Wenlock	Perry Mountain Formation		
Silurian	Llandovery	Rangeley Formation	Sangerville Formation	Waterville Formation Mayflower Hill (now Sangerville) Formation

Figure 4. Correlations across the area west of the Kingman fault zone. After Ludman, 1976.

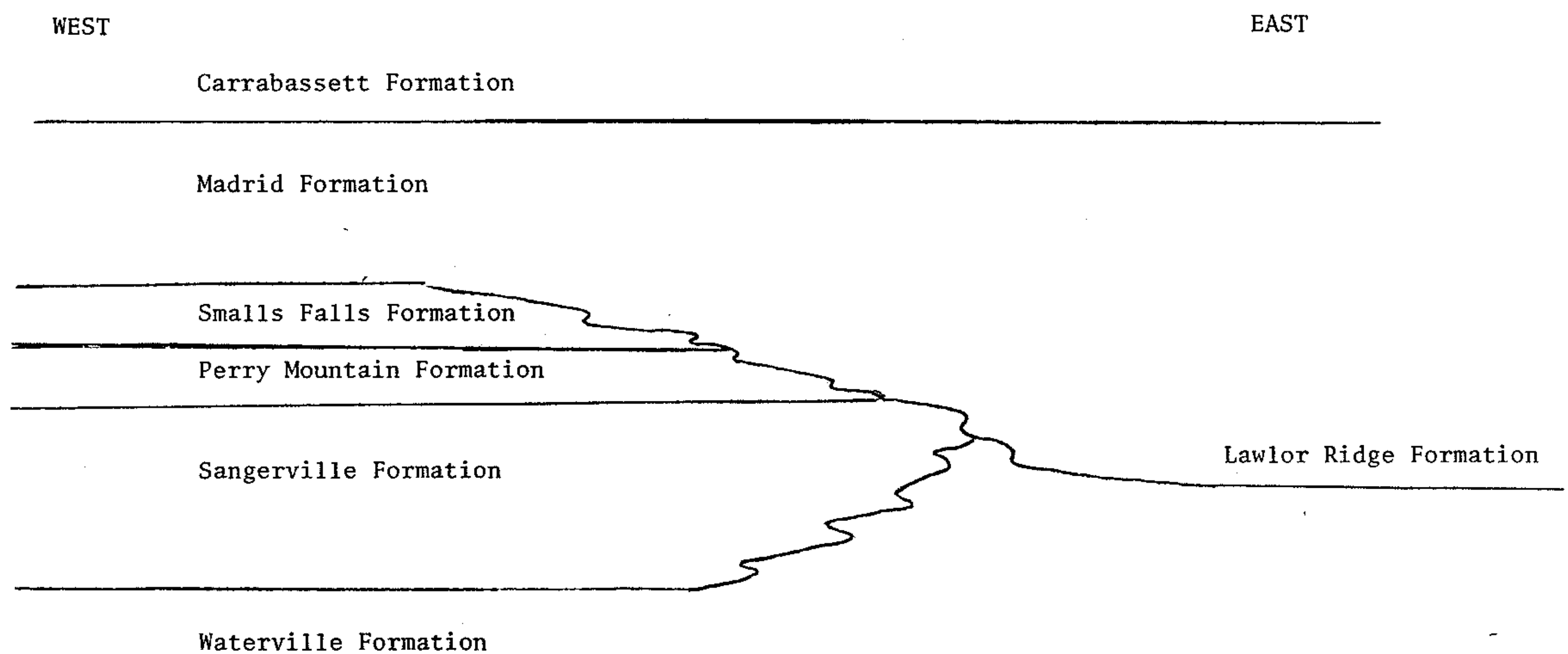


Figure 5. Correlation across the study area.
Based on sketch drawn by Allan Ludman, 1985.

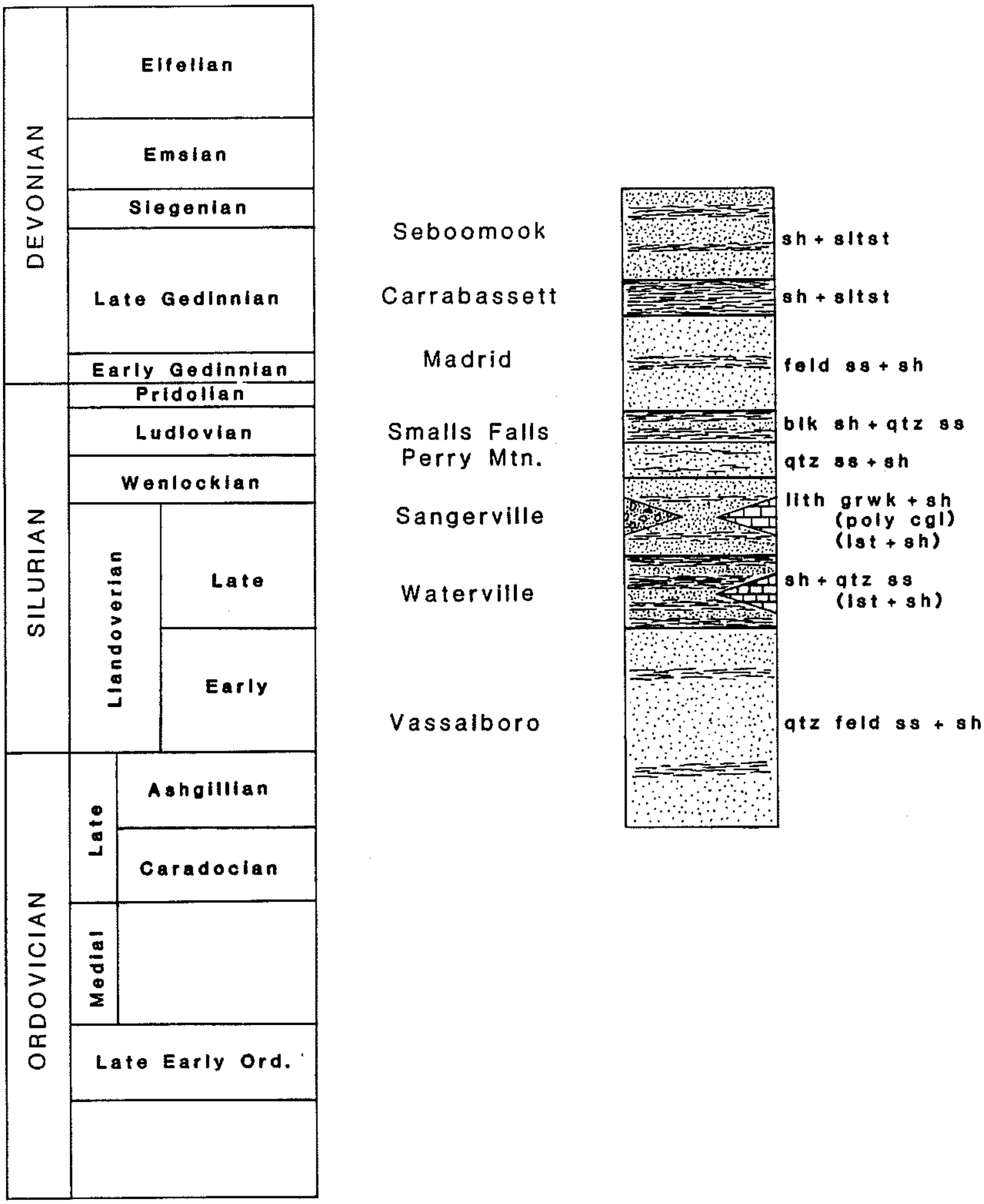


Figure 6. Presently accepted stratigraphic column for the area west of the Kingman fault zone. From Morisi, 1986.

shale, the Vassalboro Formation is described as being similar to the Siluro-Devonian aged Madrid (then called Fall Brook) Formation by Ludman and Griffin (1974). Early work suggested that the two formations were correlative (Osberg, Moench, and Warner, 1968; Griffin, 1973; Ludman and Griffin, 1974; Ludman, 1976; see figures 2 to 4, this report), but later work suggests that the Vassalboro Formation is older, lying instead below the Waterville Formation in the stratigraphic column (Osberg, Hussey, and Boone, 1985; see figure 6, this report).

Silurian

Waterville Formation: As described by Osberg (1968), the Waterville Formation is divided into two facies. The western facies is composed of greenish-gray pelite, with quartz wacke, gray limestone, and minor black phyllite. The eastern facies, which is the facies exposed in the study area, is composed of thinly laminated greenish-gray phyllite, with a prominant limestone member. Griffin (1973) felt that this limestone member could be traced across the Waterville-Sangerville boundary, and thus that the two formations were the same age (figure 3).

Sangerville Formation: The dominant member of the Sangerville Formation is composed of graded beds of sandstone and siltstone with lesser amounts of shale.

Bedding thickness ranges from 8 cm to 1 m. This unit is poorly sorted, slightly calcareous, and contains large muscovite flakes and a ferroan carbonate that weathers to hematite, producing a rusty weathering rind. The Sangerville is similar to the Vassalboro and Madrid Formations except for the presence of several distinctive members: granule conglomerate and ribbon limestone, both of which occur as lenses and bands, and carbonaceous shale. Griffin (1973) believed that the Sangerville Formation interfingered with the equivalent age Waterville Formation (figure 3).

Perry Mountain Formation: This is a cyclically bedded quartz-rich sandstone and muscovite-rich shale. Osberg, Moench, and Warner (1968) correlated the Perry Mountain Formation with the Waterville Formation; its presently accepted position above the Sangerville Formation is shown in figure 6.

Smalls Falls Formation (Eddy Formation of Ludman, 1976; Parkman Hill Formation of Pankiwskyj et al., 1976; and Ludman and Griffin, 1974). This formation is described as dominantly a sulfidic carbonaceous shale, which alternates with less common quartzose sandstone and noncarbonaceous shale. Ludman (1976) says that the sandstones of the Smalls Falls Formation may be distinguished from those of the Sangerville Formation because the former are thicker bedded, with less-well-developed graded bedding and no argillaceous matrix. Quartz clasts dominate in the Smalls Falls Formation. Osberg, Moench, and Warner (1968) and Ludman (1976) state that the Smalls Falls Formation is the age of the top of the Waterville Formation, and Ludman (1976) also states that it conformably overlies the Sangerville Formation in the Kingsbury/Skowhegan area. Pankiwskyj et al. (1976) and Ludman and Griffin (1973) suggest that it thins to the east and interfingers with the Sangerville Formation. Its existence in the study area is still problematical, as will be discussed in the map section of this paper.

Silurian-Devonian

Madrid Formation (Fall Brook Formation of Griffin, 1973; Ludman and Griffin, 1974; and Pankiwskyj et al., 1976; Brighton Formation of Ludman, 1976). The Madrid Formation is a thick-bedded, slightly calcareous sandstone and siltstone with minor shaley beds and partings. Ludman and Griffin (1974) and Pankiwskyj et al. (1976) describe its contact with the overlying Carrabassett Formation (then called Solon Formation) as gradational. In appearance the Madrid Formation is similar to both the Sangerville and the Vassalboro Formations. Newberg (1983) suggests that the Madrid Formation may be distinguished from the Sangerville Formation because the Madrid Formation lacks the rusty weathering of the Sangerville Formation, lacks its bedding plane fissility, has a "more angular break", and is better sorted and cemented. As mentioned in the description of the Vassalboro Formation, earlier work suggested that the Vassalboro and Madrid Formations were correlative (Osberg, Moench, and Warner, 1968; Griffin, 1973; Ludman and Griffin, 1974). Later work has thrown this interpretation into question by suggesting that the Vassalboro Formation may be older than the Waterville Formation, instead of younger (Osberg, Hussey, and Boone, 1985).

Devonian

Carrabassett Formation (Solon Formation of Pankiwskyj et al., 1976). This is dominantly a dark gray, rhythmically graded pelite, with lenses of granule conglomerate near its base.

Problems in assigning outcrops to one of these formations stem from two sources. The first is that, when seen in isolation, many of these formations are identical. For example, it can be impossible to tell if an outcrop of sandstone belongs to the Vassalboro, Sangerville, or Madrid Formation without some knowledge of what the rocks around it are like. This is complicated by the second problem, the scarcity of outcrop. Previous workers have estimated that 1% of the area is outcrop. Given the paucity of distinguishing characteristics, this makes correlating from outcrop to outcrop difficult indeed. Westerman (1983) responded to these difficulties in an innovative fashon. He declared that in this area the stratigraphy outlined above was unworkable. In its place, he described six units and then mapped the Guilford, Dover-Foxcroft, and Boyd Lake Quadrangle in terms of these units. His lithologic descriptions and map are given as figure 8. While this approach simplies the stratigraphy and structure of this area greatly, it does make correlations with the surrounding world quite difficult.

East

The stratigraphic relationships for the area to the east and north of the Kingman fault zone are shown in figure 7. For more complete descriptions of the units than will be given here, the reader is referred to Ekren and Frischknecht (1967), Neuman (1967), Pavlides (1974), Roy (1981), Roy, Demorest, and Hill (1983), and Morisi (1986). The descriptions given here are a composite of those in these references; I did not work with these units last summer. Possible correlations with the units to the west of the Kingman fault zone are given after the descriptions.

Ordovician-Silurian

Mattawamkeag Lake Formation: This unit is evenly divided between graywacke and slate. It is believed to be the same

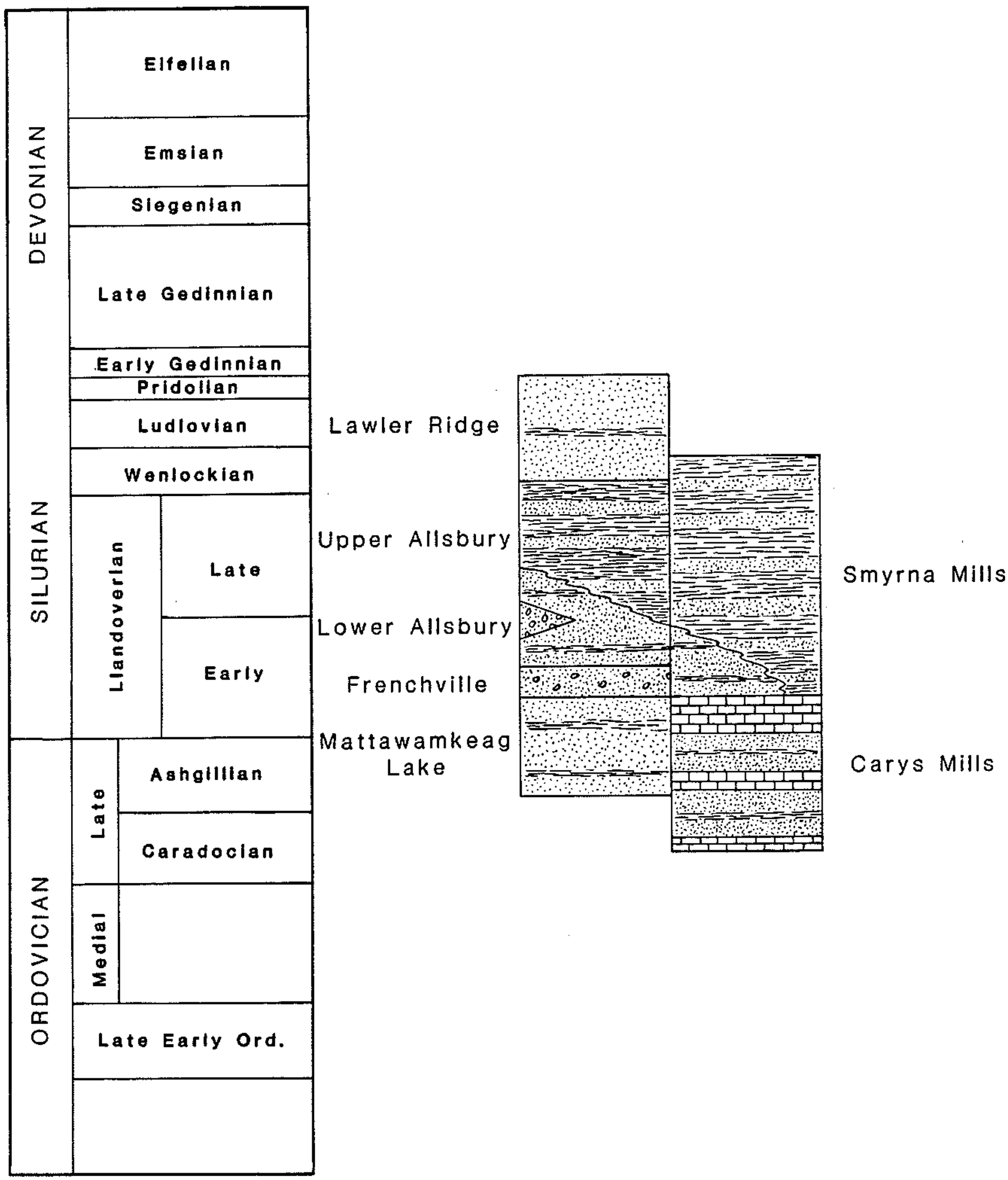


Figure 7. Stratigraphic relations in the area east of the Kingman fault zone. From Morisi, 1986.

age as the Carys Mills Formation, which is exposed farther to the east (figure 9). The Carys Mills is dominantly an impure limestone, and has been assigned an age of Middle Ordovician to Early Silurian.

Silurian

Frenchville Formation: Dominantly a graywacke, the Frenchville Formation is lithologically similar to the overlying Sandstone member of the Allsbury Formation.

Allsbury Formation: This unit has been subdivided into a lower Sandstone and an upper Slate Member. The Sandstone Member as used by Roy, Demorest, and Hill (1983) contains greater than 30% sandstone with beds commonly thicker than 30 cm and locally thicker than 1 m. The sandstone is a quartz-rich graywacke. The Slate Member, again as used by Roy, Demorest, and Hill (1983), is at least 75% slate. The sandstone beds are of the same composition as those in the Sandstone Member, but are thinner-bedded and finer-grained. Neuman (1967) described the Sandstone Member as underlying the Slate Member, but Roy, Demorest, and Hill (1983) suggested that instead they are in part facies equivalents, and represent submarine fan deposits. The Allsbury is believed to be the same age as the lithologically similar Smyrna Mills Formation, exposed farther to the east (figure 9).

Lawlor Ridge Formation: Roy (1981) proposed the name Lawlor Ridge Formation for a sequence of thick-bedded graywacke with minor shaley beds. This formation is lithologically similar to the Madrid Formation and has been mapped as such on the Bedrock Geologic Map of Maine (Osberg, Boone, and Hussey, 1985).

As is apparent from the descriptions of the formations found to the west and east of the Kingman fault zone, the zone separates very similar rock sequences. Several correlations can be suggested between these sequences. As noted above, the Lawlor Ridge Formation is believed to be the equivalent of the Madrid Formation, and has been mapped as such (Osberg, Hussey, and Boone, 1985). The Smalls Falls and Perry Mountain Formations do not have obvious equivalents to the east, but this may be because these units have pinched out west of the Kingman fault zone. There are problems in correlating the Sangerville and Waterville Formations with the upper and lower Allsbury Formation. To the west, the dominantly graywacke unit overlies the dominantly pelitic, while to the east the sequence is reversed. This problem can be overcome if the stratigraphy is not a simple layer cake model, but instead a more complex model of interfingering relationships such as would be found in a series of coalescing submarine fans (Roy, Demorest, and

Hill, 1983; Ludman, oral communication, 1985). A Sangerville-equivalent may not be present in the eastern sequence; several workers have suggested that the Waterville Formation is at least in part equivalent to the Sangerville, and that the Sangerville Formation interfingers with the Waterville Formation to the east (Ludman and Griffin, 1974; Ludman, 1976; see figures 3 and 5, this report). If this is the case, then the upper Slate Member of the Allsbury Formation might correlate with the Waterville Formation, and the lower Sandstone Member of the Allsbury Formation plus the Frenchville and Mattawamkeag Lake Formations would correlate with the Vassalboro Formation. In any case, these similarities imply that the Kingman fault zone, at least for these Silurian-age rocks, does not represent a major discontinuity, a conclusion also reached by Ludman (1986).

Maps

Several workers, most notably John Griffin, have mapped in the study area. A number of these previous maps are reproduced here as figures 8 to 10. Striking differences are apparent in even a cursory examination of these maps. Some workers, for example John Griffin (1976), defined new formations, such as the "Kenduskeag Formation", which never were formally accepted. Griffin also subdivided formations into members and attempted to see if these members were viable map units. Many of these members have only a patchy distribution (figure 10), and have not been used by subsequent workers. On the other hand, other workers, exemplified by David Roy (1981), broke out very few members and formations (see area around Millinocket, figure 9). This reflects either a difference in mapping style or a difference in the variety of rock typrs present. Finally, as mentioned earlier, Westerman (1983) decided to define a new set of mapping units, in an attempt to deal with correlation problems caused by the similarities of the units in the classic stratigraphic sequence and the lack of outcrop (figure 8). In this section I will concentrate on what seem to me to be a few key questions raised by the differences seen on these maps.

On the Bedrock Geologic Map of Maine, the Kingman fault zone appears as a zone against which the Sangerville, Perry

Figure 8. Map and lithologic units of Westerman, 1983.

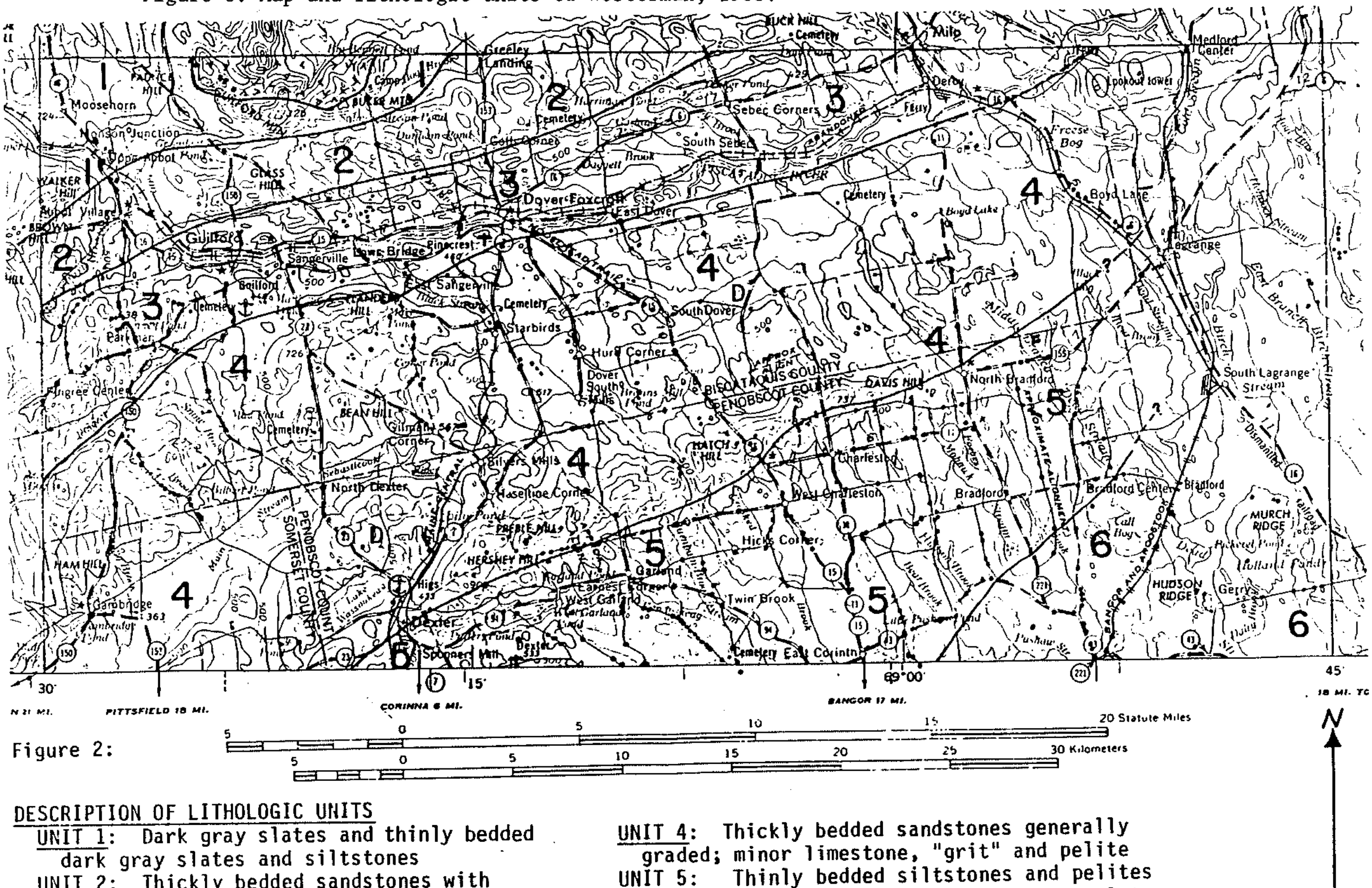


Figure 2:

DESCRIPTION OF LITHOLOGIC UNITS

UNIT 1: Dark gray slates and thinly bedded dark gray slates and siltstones

UNIT 2: Thickly bedded sandstones with minor pelitic horizons

UNIT 3: Granule conglomerates, ribbon limestones and graphitic, sulfidic pelites

UNIT 4: Thickly bedded sandstones generally graded; minor limestone, "grit" and pelite

UNIT 5: Thinly bedded siltstones and pelites with ribbon limestone and maroon/green slates

UNIT 6: Thickly bedded sandstones generally graded; minor thin-bedded siltstones and slates

D = outcrop of diabase • = outcrop location (pluton symbol) = Sebec Lake pluton

LIST OF FORMATIONS

Figure 9. From Osberg, Hussey, and Boone, 1984.

Formations are grouped by age or age range, and are listed alphabetically within each age range with members of a formation grouped beneath each formation. Strict adherence to the Stratigraphic Code has not been attempted owing to variations in usage in different sources. Formations with paleontological control on their geologic age are indicated by an asterisk; references to the paleontological information are given in parentheses (see Stratigraphic Correlation Chart). The letter corresponding to the formation protolith is given to the right of each formation. A "+" indicates that the undivided formation does not occur on the geologic map, so no protolith is indicated. If a formation symbol is shown for any of these undivided formations, it occurs only on the cross sections or stratigraphic correlation chart.

Kv	Mafic to felsic volcanic rocks		W
Msv	Mafic to felsic volcanic rocks		W
CDs	Unnamed conglomerates and sandstones		H
*Db	Beck Pond Limestone	(33,34)	S
Dc	Carrabassett Formation		A
* Dcm	Massive pelite member	(66)	A
Dcq	Quartzite member		F
Dcs	Thinly layered member		Q
*Dch	Chapman Sandstone	(36)	D
De	Eastport Formation		+
Deb	Basalt member		V
* Dep	Pelite member	(13,15)	A
Dev	Mafic to felsic volcanic member		W
Deh	Edmunds Hill Andesite		U
Dh	Hildreths Formation		S
*Dhb	Hobbstown Formation	(33,34)	H
Dhd	Hedgehog Formation		W
Dhm	Heald Mountain Rhyolite		T
Dhmd	Dark tuff member		T
Dhr	Hartin Formation		L
Dim	Ironbound Mountain Formation		A
*Dl	Littleton Formation	(20)	Q
*Dm	Mapleton Formation	(36)	H
*Dmg	Matagamon Sandstone	(207)	F
	Perry Formation		+
Dpb	Basalt member		V
* Dpsm	Sandstone member	(12,219)	H
*Dpk	Parker Bog Formation	(33,34)	M
*Ds	Seboomook Formation	(33,34,106)	Q
Dsd	Day Mountain Member		Q
Dsdl	Limestone		N
Dsdc	Conglomerate		I
Dst	Temple Stream Member		C
Dsm	Mount Blue Member		Q
Dsc	Camera Hill Greenstone		V
Dscg	Unnamed conglomerate		I
Dsq	Unnamed quartzite		F
Dsug	Unnamed mafic greenstone		V
Dsup	Unnamed pelite		A
*Dsb	Swanback Formation	(36)	A
*Dt	Tarratine Formation	(33,34)	E
Dtm	Misery Quartzite		F
* Dtmc	McKenny Pond Limestone	(33,34)	S
*Dto	Tomhegan Formation	(33,34)	E
	Kineo Rhyolite Member		+
* Dtokv	Tuffs and volcaniclastic rocks	(33,34)	T
Dtokg	Garnet rhyolite		T
Dtokm	Massive felsite		T
Dtr	Traveler Rhyolite		+
Dtrb	Black Cat Member		T
Dtrp	Pogy Member		T
*Dtv	Trout Valley Formation	(6,7)	H
Duc	Unnamed conglomerate		I
Dulc	Unnamed limestone conglomerate		M
Dup	Unnamed pelite		A
Durg	Unnamed garnet rhyolite		T
Dury	Unnamed rhyolite		T
Dus	Unnamed sedimentary rocks		Q
Duss	Unnamed lithic sandstone and conglomerate		D
Duvm	Unnamed mafic volcanic rocks		V
*Dw	Whiskey Quartzite	(33,34)	F
*	Allagash Lake Formation	(72)	+
DSas	Mixed sedimentary rocks		S
DSav	Basalt and mixed sedimentary rocks		V
	Bell Brook Formation		+
DSbbc	Conglomerate member		I
* DSbbs	Pelite member	(190)	A
DSbh	Bar Harbor Formation		E
*DSca	Castine Formation	(46)	W
DScd	Calderwood Formation		Q
DSd	Daggett Ridge Formation		H
*DSfh	Fogelin Hill Formation	(215)	Q
DSfp	Frost Pond Shale		A
*DSfri	Fish River Lake Formation	(24)	S
DSm	Madrid Formation		M

	Rindgemere Formation		+
DSra	Acton Member		Q
DSrb	Bauneg Beg Member		R
DSrbl	Limestone		N
DSrbr	Sulfidic pelite		C
*DSs	Undifferentiated sedimentary rocks of the Spider Lake, Chandler Pond, and Third Lake Formations	(106)	S
DSt	Towow Formation		C
DStc	Conglomerate member		I
*DStf	Thorofare Andesite	(46)	W
DSuc	Unnamed conglomerate		I
DSus	Unnamed sedimentary rocks		Q
DSuss	Unnamed conglomeratic sandstone		I
DSuv	Unnamed volcanic rocks		W
*DSv	Undifferentiated volcanic rocks of the Spider Lake and Chandler Pond Formations	(106)	U
DSvh	Vinalhaven Rhyolite		W
DOb	Bucksport Formation		M
DOdg	Digdeguash Formation		Q
DOf	Flume Ridge Formation		M
DOs	Spruce Top Greenstone		V
DOup	Unnamed pelite		A
DOv	Undifferentiated mafic to felsic volcanic rocks		W
D€us	Unnamed sedimentary rocks		Q
DZar	Appleton Ridge Formation		A
DZg	Gonic Formation		A
*Sak	Ames Knob Formation	(46)	S
Sbb	Burnt Brook Formation		A
Sc	Capens Formation		A
Scgu	Undifferentiated conglomerates and coarse-grained sandstones, in part of the Allsbury Formation and in part unnamed		I
*Sd	Dennys Formation	(15)	+
Sdb	Basalt member		V
Sdv	Mafic to felsic volcanic rock member		W
*Se	Edmunds Formation	(15)	W
*Sf	Frenchville Formation	(36,215)	H
*Sfm	Rocks of the Fivemile Brook Sequence	(43)	B
Sfmg	Greenstone		V
Sg	Greenvale Cove Formation		J
*Sh	Hersey Formation	(13)	Q
*Shm	Hardwood Mountain Formation	(33,34)	S
*Sj	Jemtland Formation	(215)	Q
Sl	Leighton Formation		+
Slb	Basalt member		V
* Slp	Pelite member	(13,15)	A
Slv	Mafic to felsic volcanic rock member		W
*Smm	Maple Mountain Formation	(189)	Q
*Sns	New Sweden Formation	(215)	B
*So	Oak Bay Formation	(56)	H
Sp	Perry Mountain Formation		Q
Spu	Undifferentiated pelites and sandstones, in part of the Allsbury Formation and in part unnamed		Q
Sq	Quoddy Formation		+
* Sqp	Pelite member	(12,15)	A
Sqv	Mafic to felsic volcanic rock member		W
Sqvu	Undifferentiated volcanic rock member		X
Sr	Rangeley Formation		Q
Sra	"A" member		Q
Srac	Lithic sandstone		H
Srb	"B" member		Q
* Src	"C" member	(159,161)	Q
Srm	Rocky Mountain Quartz Latite		T
*Srp	Ripogenus Formation	(37,101,240)	L
*Ss	Sangerville Formation	(16,179,188)	R
Ssa	Anasagunticook Member		Q
Ssal	Limestone		N
	Sulfidic pelite		C

*Saf	Smalls Falls Formation	(188)	C
*Sam	Smyrna Mills Formation	(197)	Q
*Sapr	Spragueville Formation	(191,192)	R
Sau	Undifferentiated sandstones, in part of the Allsbury Formation and in part unnamed		D
*Stf	The Forks Formation	(203)	O
*Suc	Unnamed conglomerate	(169)	I
Sucs	Unnamed conglomeratic sandstone		H
Sul	Unnamed limestone		N
Sup	Unnamed pelite		A
Sur	Unnamed sulfidic pelite		C
Sus	Unnamed sedimentary rocks		S
Suss	Unnamed sandstone		Q
Suvm	Unnamed mafic volcanic rocks		V
Suvs	Unnamed volcanic and sedimentary rocks		W
*Sw	Waterville Formation	(179,198)	Q
Swl	Limestone member		M
Swb	West Branch Volcanic Rocks		W
*Sww	Waweig Formation	(199)	A
*SOar	Aroostook River Formation	(215)	Q
*SOcm	Carys Mills Formation	(192,197,208)	R
SOcml	Lower member		Q
SOcms	Pelite member		A
SOdb	Dunn Brook Formation		W
SOf	Frontenac Formation		Q
SOfc	Canada Falls Volcanic Member		V
SOlb	Lobster Lake Formation		H
SOm	Mattawamkeag Formation		Q
*SOmh	Mars Hill Conglomerate	(170)	I
*SOn	Nine Lake Formation	(190)	Q
*SOuc	Unnamed conglomerate	(169)	I
SOup	Unnamed pelite		A
SOur	Unnamed sulfidic pelite		C
SOus	Unnamed sedimentary rocks		Q
SOuv	Unnamed volcanic rocks		W
*SOv	Vassalboro Formation	(188)	M
SOvv	Volcanic member		T
SZb	Berwick Formation		K
SZe	Eliot Formation		B
SZk	Kittery Formation		K
Oam	Ammonoosuc Volcanics		W
*Obb	Blind Brook Formation	(106)	C
*Obh	Benner Hill Formation	(35)	Q
Obhs	Sulfidic pelite member		C
Obl	Belle Lake Slate		A
*Obp	Bluffer Pond Formation	(106)	V
Obpr	Rhyolite member		T
*Ocl	Chase Lake Formation	(106)	H
* Ocls	Sandstone and pelite member	(106)	A
* Oclc	Conglomerate member	(106)	I
Ocr	Chandler Ridge Formation		Q
	Rocks of the Depot Mountain Sequence		+
* Odmp	Sandstone/pelite	(43,170)	Q
Odms	Graywacke		K
Odmu	Undivided		+
Odmv	Tuff		T
Odw	Dry Wall Volcanic Rocks		V
Ohh	Holmes Hole Formation		C
*Ok	Kennebec Formation	(33,34)	T
*	Kamankeag Formation	(110)	+
Okmg	Basalt and graywacke member		E
Okms	Pelite member		C
*Olm	Lobster Mountain Volcanic Complex	(33)	W
Olma	Andesite member		U
Olmb	Basalt member		V
*Om	Madawaska Lake Formation	(215)	Q
*Oml	Munsungun Lake Formation	(106)	T
*Opm	Pile Mountain Argillite	(36)	A
Oq	Quimby Formation		Q
Oqg	Graywacke member		D
Oqs	Pelite member		Q
Oqv	Rhyolitic volcanic member		T
*Osb	Shin Brook Formation	(168,169)	U
Oup	Unnamed pelite		A
Our	Unnamed sulfidic pelite		C
Ous	Unnamed sandstone and pelite		Q
Ouss	Unnamed sandstone		M
Oussp	Unnamed quartz sandstone and pelite		Q
Ouv	Unnamed volcanic rocks		W

Ouvm	Unnamed mafic volcanic rocks		V
Ouvs	Unnamed volcanic and sedimentary rocks		W
*Ow	Winterville Formation	(215)	V
*Owc	Wassataquoik Chert	(169)	P
O€b	Mount Battie Formation		I
O€c	Cookson Formation		C
O€cqr	Sulfidic quartzose sandstone		G
* O€cr	Sulfidic pelite	(56,217)	C
O€css	Lithic sandstone and pelite		Q
O€cv	Mafic to felsic volcanic rocks		W
O€cb	Chase Brook Formation		Z
O€d	Dead River Formation		Q
O€dq	Upper member		F
O€dp	Lower member		Q
O€hm	Hurd Mountain Formation		Z
O€hmb	Basalt member		V
O€me	Megunticook Formation		A
O€mec	Polymictic conglomerate member		I
O€mel	Limestone member		N
O€p	Penobscot Formation		C
O€pg	Basalt member		V
O€pmig	Extensively migmatized areas		C
O€s	Sawmill Formation		Q
O€sc	Southeast Cove Formation		Q
O€sd	Saint Daniel Formation		Z
O€sdq	Quartzite and red and green shale		F
O€us	Unnamed sedimentary rocks		Q
O€uv	Unnamed volcanic rocks		W
O€w	Aziscohos Formation		A
OZc	Cushing Formation		W
OZcg	Mafic volcanic member		V
OZcl	Limestone member		N
OZcq	Quartzite member		F
OZcr	Sulfidic pelite member		C
OZce	Cape Elizabeth Formation		Q
OZceq	Quartzite member		F
OZcev	Mafic to felsic volcanic member		W
OZcf	Columbia Falls Formation		X
OZe	Ellsworth Formation		Q
OZef	Quartz granofels member		T
OZev	Greenstone member		V
OZj	Jewell Formation		C
OZm	Macworth Formation		B
OZs	Spring Point and Diamond Island Formations		W
OZsc	Scarboro Formation		C
OZsk	Spurwink Limestone		N
OZugn	Unnamed gneiss		W
OZul	Unnamed limestone		N
OZus	Unnamed sedimentary rocks		Q
OZuvf	Unnamed felsic volcanic rocks		T
€b	Boil Mountain Ophiolite		+
€cl	Caucomgomoc Lake Formation		+
€clg	Basalt member		V
€clf	Quartzwacke and pelite member		D
*€gp	Grand Pitch Formation	(167,169)	Q
€h	Hurricane Mountain Formation		Z
€ha	Amphibolite and greenschist		V
€hpx	Pyroxenite		
€hq	Black and gray metaquartzite		F
€hqw	Metaquartzwacke		E
€hr	Metafelsite		T
€j	Jim Pond Formation		W
€jf	Quartzwacke and pelite		D
€jg	Mafic volcanic rocks		V
€jk	Felsic volcanic rocks		T
€jp	Siltstone, mudstone, and pelite		Q
€jq	Graywacke		E
€ls	Loon Stream Formation		Q
€uvm	Unnamed mafic volcanic rocks		V
Zcb	Coombs Limestone		N
Zi	Rocks of Islesboro		Q
Zil	Limestone		N
Znh	North Haven Formation		V
Zop	Ogier Point Formation		Q
Zr	Rye Formation		Q
Zrk	Rockport Formation		I
pZc	Gneisses of the Chain Lakes Massif		Y

Figure 9. From Osberg, Hussey, and Boone, 1984.
Scale = 1/500,000

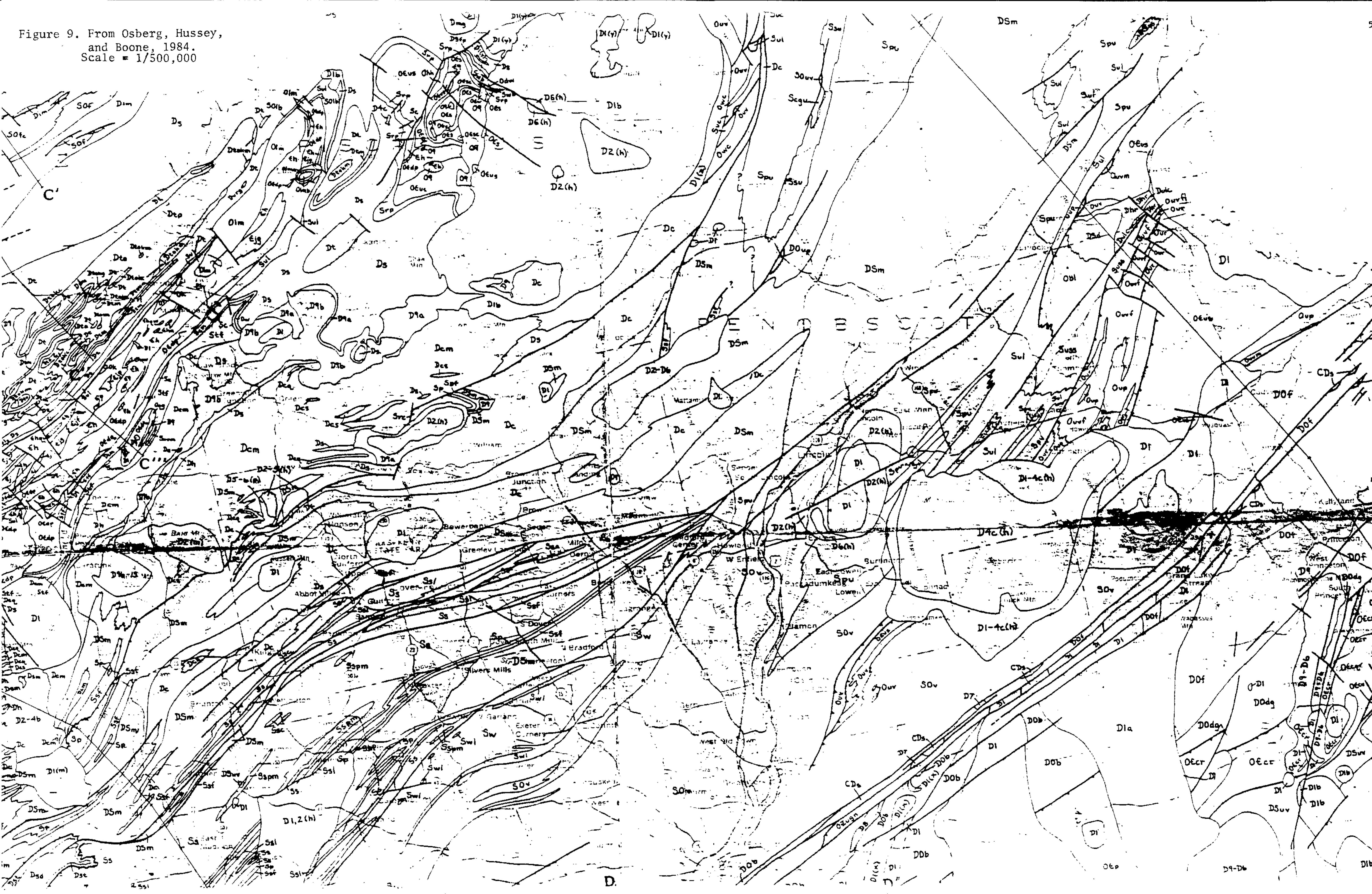


Figure 9. From Osberg, Hussey, and Boone, 1984.
Scale = 1/500,000

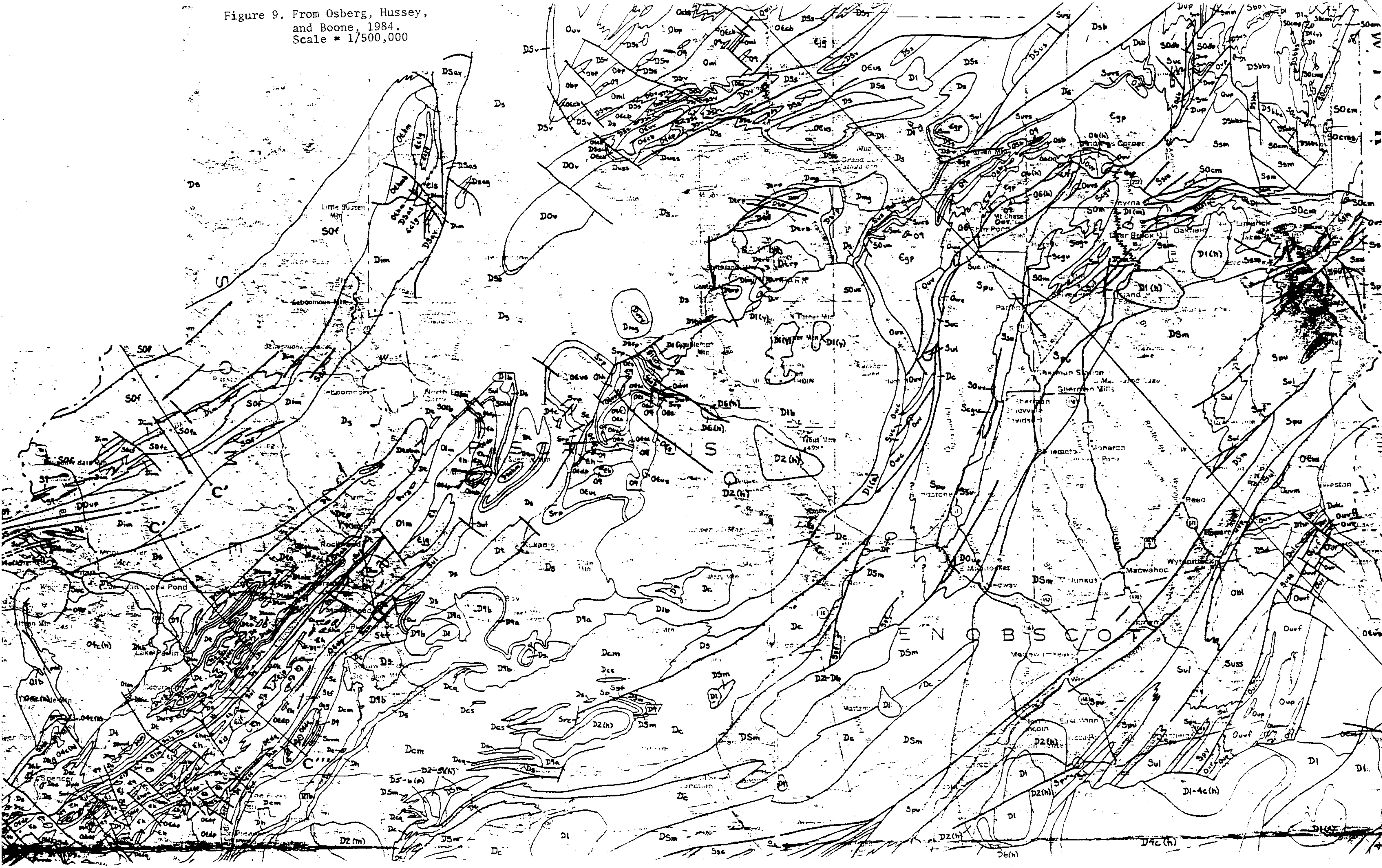
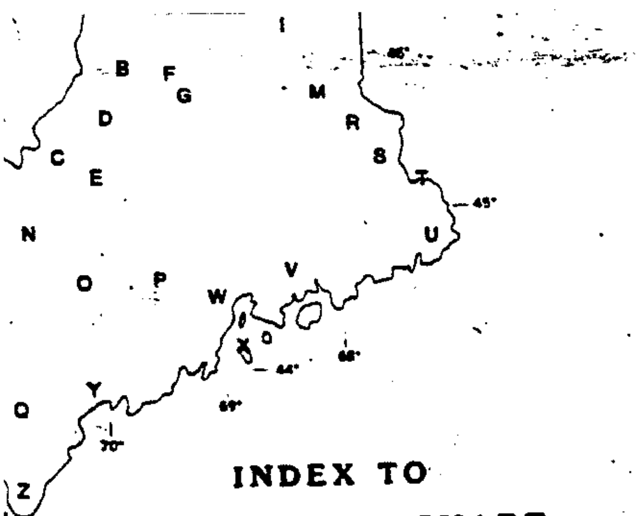


Figure 9. From Osberg, Hussey, and Boone, 1984



INDEX TO CORRELATION CHART

Unconformity

Tectonic contact

Asterisk indicates formation with fossil control on geologic age; see List of Formations for references to paleontological information.

STRATIGRAPHIC CORRELATION CHART

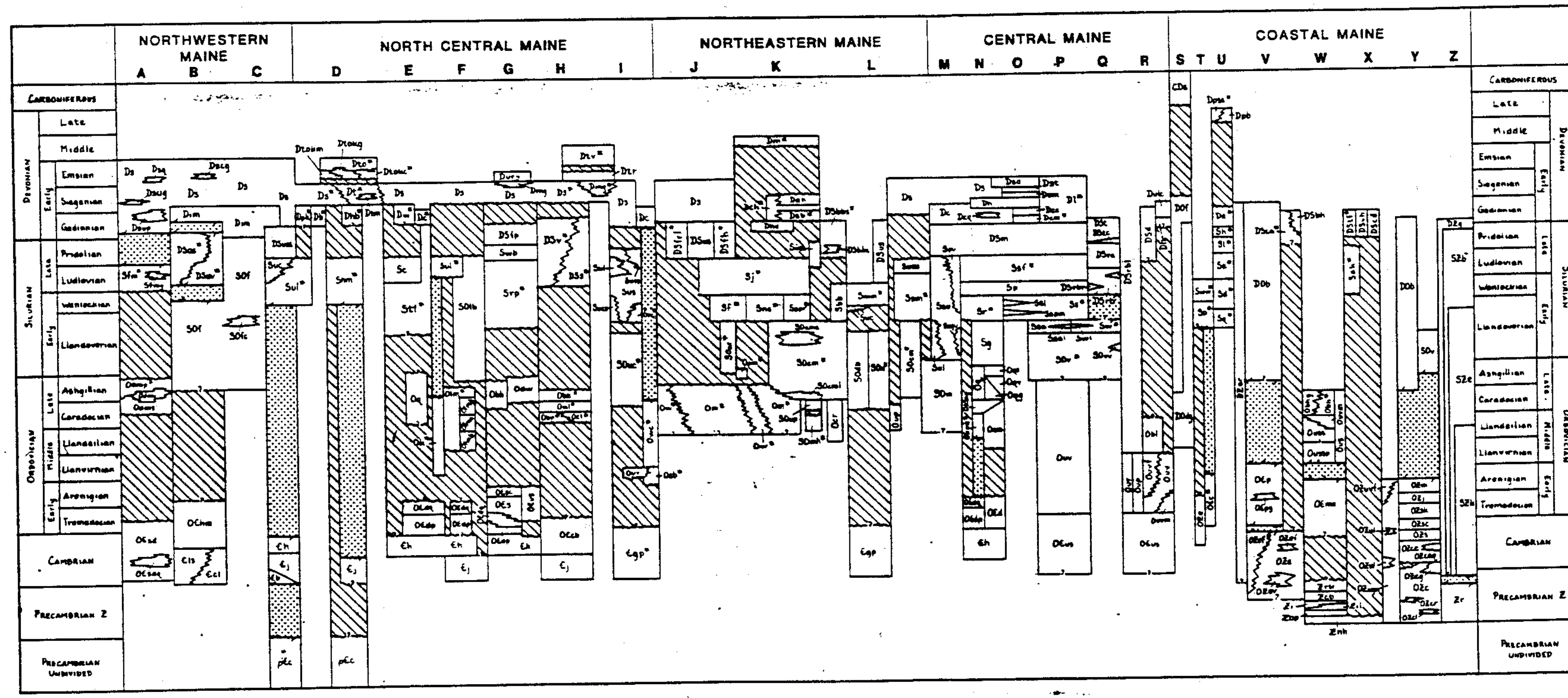


Figure 10. From Griffin, 1976.

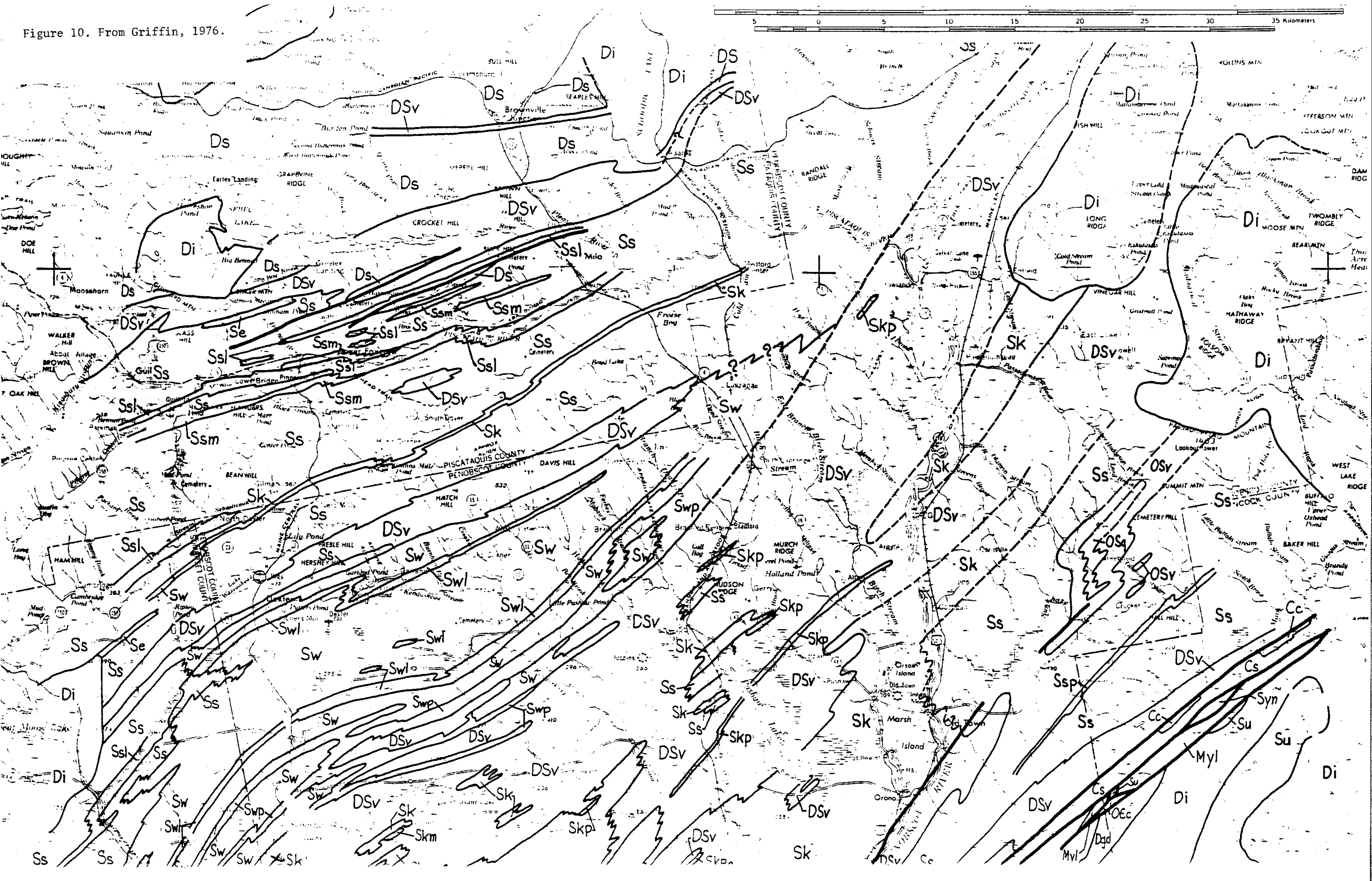


Figure 10. From Griffin, 1976.

EXPLANATION

INTRUSIVE ROCKS

Syn	Turner Mountain Syenite; coarse-grained, medium to dark red-brown, hornblende-biotite, porphyritic syenite.
Myl	Mylonite, fine-grained, white to light green, feldspathic.
Di	Granitic intrusive rocks.
Dgd	Diorite, medium-grained, dark gray, orthoclase-biotite-pyroxene-quartz.
ЄOi	Winterport Granite; foliated granitic rock.
Bi	Brewer Lake or Stricklen Ridge Intrusive; muscovite-biotite granite with inclusions of Passagassawaukeag Gneiss and Copeland Schist.

METAMORPHOSED BEDDED ROCKS

Cℙc	Roundstone conglomerate, light red.
Cℙs	Siltstone and arkosic sandstone, dark red.
Ds	Solon Formation; metasiltstone and slate, dark gray, cyclically bedded, beds 5-10 cm. thick.
DSv	Vassalboro and Fall Brook Formations; massive, beds 0.3-1.8 m. thick, fine to medium grained, feldspathic wacke, 8-15 cm. thick interbeds of dark gray phyllite, minor black carbonaceous phyllite and feldspathic coarse sand to granule conglomerate.
Su	Undifferentiated metasediments of probably Silurian age; massive quartzite, metasiltstone, and phyllite.
Ss	Sangerville Formation; beds 0.1-0.6 m. thick, graded calcareous quartzite with phyllitic tops, phyllitic portions of the beds 5-10 cm. thick, interbedded with dark gray to black phyllitic slate, sometimes rusty weathering.
Ssl	Limestone member; 1.2-7 cm. thick layers, silty limestone interbedded with calcareous siltstone and sandstone.
Ssm	Conglomerate member; 0.6-2 m. thick beds of granule-size polymictic conglomerate containing quartz, plagioclase, orthoclase, volcanic fragments, chert, quartzite, and slate.
Ssp	Maroon and green member; 3-12 mm. thick layers of maroon and green metasiltstone, phyllite, and slate.
Sw	Waterville Formation; 0.3-1.2 cm. thick layers of phyllite interbedded with 1.2-2.4 cm. thick layers of coarse metasiltstone to very fine quartzite, metasiltstone and quartzite layers exhibit fine internal laminae, grading, and cross-lamination, quartzite layers slightly calcareous.
Swl	Limestone member; 1.2-7 cm. thick layers, silty limestone interbedded with calcareous siltstone and sandstone.
Swp	Maroon and green member; 3-12 mm. thick layers of maroon and green metasiltstone, phyllite, and slate.
Sk	"Kenduskeag Unit"; extremely variable in bedding thickness, sequence of massive quartzite alternating with sequences of 0.6-2.4 cm. thick interbedded phyllite and metasiltstone, portions of the unit consist of sedimentary breccia and chaotic zones of slump origin.
Skl	Limestone member; 1.2-7 cm. thick layers, silty limestone, interbedded with calcareous siltstone and sandstone.
Skm	Conglomerate member; 0.6-2 m. thick beds of granule-size polymictic conglomerate containing quartz, plagioclase, orthoclase, volcanic fragments, chert, quartzite, and slate.
Skp	Maroon and green member; 0.3-1.2 cm. thick layers of maroon and green metasiltstone, phyllite, and slate.

Mountain, and Smalls Falls Formations terminate, and which places the Madrid Formation in contact with the Waterville Formation. Thus it appears that there is significant stratigraphic offset across the zone. However, this is not necessarily the case. Comparison of the map of Griffin (1976; figure 10 this report) with the Bedrock Geologic Map of Maine (figure 9) reveals several differences in the Boyd Lake Quadrangle. In particular, the state map has the Perry Mountain and Smalls Falls Formations cutting across the northwest corner of the quadrangle, separating Madrid Formation in the northwest from Sangerville Formation in the southeast (figure 9). Griffin's map instead has the Sangerville Formation in the northwest corner, in place of the Madrid Formation, with the Sangerville Formation in contact with the Waterville Formation in the southeast. No Perry Mountain or Smalls Falls Formation is found in this area on his map (figure 10). Allan Ludman (oral communication, 1985) confirms Griffin's identification of the outcrops in the northwest as Sangerville Formation, not Madrid Formation, and Lillian Morisi (oral communication, 1986) confirms that she was unable to find any Smalls Falls or Perry Mountain Formation rocks near the Piscataquis River. It is possible that these units pinch out stratigraphically west of the Boyd Lake Quadrangle, and are not cut out in a fault zone. If the Sangerville and the Waterville Formations are facies equivalents, then the

Sangerville Formation may not terminate against the fault zone either, but instead may interfinger with the Waterville Formation in the vicinity of the fault zone.

On the Bedrock Geologic Map of Maine (Osberg, Hussey, and Boone, 1985) the rocks of the Kingman fault zone are labelled Silurian unnamed pelites (Spu). The relationship between these pelites and those in the stratigraphic sequences to either side is somewhat problematical. It is possible that these pelites correlate with the Waterville Formation to the west and/or the pelites of the Allsbury and Smyrna Mills Formations to the east.

Obviously, before the regional significance of this fault zone can be assessed, problems with the stratigraphy will have to be resolved.

Future Directions

As I indicated in the Introduction, there are two aspects to the problem of understanding the Kingman fault zone. The regional significance of this zone needs to be evaluated, and the deformation history of the zone needs to be unraveled. I believe that the most fruitful approach to understanding the regional significance of the zone will be to begin by mapping the Boyd Lake Quadrangle. This quadrangle is a good starting place for several reasons. It is the closest to the area to the west where the stratigraphy and structure are presumably better known. Also, John Griffin's work has demonstrated that in the western half of the quadrangle, at least, outcrop is relatively abundant and accessible.

In order to be able to successfully map this quadrangle, however, I feel it would be useful to make a fresh start, and not rely on previous workers' identification of units. Last summer I attempted to learn the characteristics of the formations by studying John Griffin's work. However, not everyone agrees with the way he assigned the outcrops to formations. A better way to begin, then, would be to go into the area to the west, where the formations were originally defined, and study them there first. Once this has been done, then I would go back into the Boyd Lake Quadrangle and work with the outcrops there.

The mapping in the Boyd Lake Quadrangle can then be extended to the other quadrangles to the west of the Kingman fault zone. Once the pattern here has been established, work can begin on the eastern side, again starting with an area near a well-defined stratigraphy, and extending this work up to the fault zone. In this manner, the amount of offset along the zone can be determined.

Next summer I plan to begin work on the second phase of this problem, the meso- and microstructures. I will spend from July 21 to August 1 examining the deformed rocks of the zone itself, measuring the orientations of mesostructures and collecting oriented samples for microstructural analysis with the petrographic microscope. This work should allow me to begin to say something about the deformational history of these rocks and the conditions under which they deformed.

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